The course of the secondary disturbance was to the northeastward, as indicated by arrows that cross the hour lines in Figure 3. It passed near or over St. Joseph, causing a remarkably rapid fall in pressure, and spent nearly all of its energy before reaching extreme east-central Iowa. Its rate of movement seems to have been greater than the rate of advance of the primary storm area.

It should be noted that (1) the lowest pressure at Kansas City was 0.09 inch higher than the lowest pressure at St. Joseph, thus giving evidence of a ridge of pressure between the primary and secondary depressions; (2) the direction of surface winds was not materially affected by the passage of the secondary whirl; (3) the velocity of surface winds was not as great as that which usually attends such wide fluctuations in pressure; and (4) assuming that the atmospheric whirl existed aloft, as outlined, it would not have been subject to the retarding influence, experienced by the primary cyclonic area, resulting from friction with the ground.

Pressure and wind conditions on November 16–17, 1928

Stations	Lowest barometer (sea level)	Time	Greatest fall in pressure within 2 hours	Maximum wind velocity, direction, and time
Nov. 16				
Oklahoma City, Okla	29.65	5:00 p. m.	0.08	20, N., 9:34 p. m.
Fort Smith, Ark	29.72	10:00 p. m.	.06	30, SW., 10:04 p. m.
Nov. 17				
Wichita, Kans	29.64	1:30 a. m.	.20	32, NE., 1:36 a. m.
Iola, Kans	29.58	2:00 a. m.	.17	19, N., 7:24 p. m. (16th).
Concordia, Kans	29.92	7:10 a. m.	.07	24, NW., 9:43 a. m.
Springfield, Mo	29.58	5:00 a. m.	.13	28, W., 11:31 a. m.
Columbia, Mo	29.54	7:00 a. m.	.10	23, SW., 12:35 p. m.
Kansas City, Mo	29.61	5:00 a. m.	.17	30, NE., 5:30 a. m.
St. Joseph, Mo	29.52	5:30 a. m.	.27	25, NE., 5:22 a. m.
Omaha, Nebr	29.85	7:00 a. m.	.09	28, N., 6:45 a. m.
Des Moines, Iowa	29.62	8:30 a. m.	.21	22, N., 8:36 a. m.
Charles City, Iowa	29.77	12:00 noon	.12	17, NE., 11:35 a. m.
La Crosse, Wis	29.76	12:30 p. m.	.10	11, N., 10:34 a. m.
Davenport, Iowa	29.53	1:00 p. m.	.09	
Dubuque, Iowa	29.60	1:45 p. m.	.13	18, N., 5:12 p. m.
Keokuk, Iowa	29.57	12:00 noon	.06	18, NE., 3:28 p. m.
Hannibal, Mo	29.55	12:30 p. m.	.06	28, SW., 2:16 p. m.
St. Louis, Mo	29.63	10:00 a. m.	.07	36, W., 4:23 p. m.

NOTE

A somewhat similar phenomenon occurred on February 20, 1927, between 4 and 5 a. m. at the New York station. Mr. Gerald J. O'Connor brought this matter to the attention of the central office and remarked that he had noted a similar occurrence on May 12, 1923. In the February, 1927, case the temperature was steady at about 24°, with sleet and rain and fresh easterly winds. The barograph trace showed a sudden fall of 0.10 inch and a rise of 0.09 inch, both within the hour, 4 to 5 a. m. Similar but less accentuated conditions were noted as follows: Atlantic City, 3 a. m.; Philadelphia, 3 a. m.; Trenton, 3 to 4 a. m.; Sandy Hook, 4:15 a. m.; New York. 4:15 a. m.; Block Island, 11:15 a. m.; Providence, 11:30 a. m. But the traces at Washington, Baltimore, Harrisburg, Reading, Scranton, and New Haven showed nothing of this kind.

With steady temperatures and persistent northeast winds, without any shift at the surface, we naturally have recourse to the conditions in the free air. From the fact that sleet was falling it may be inferred that a warm current existed aloft, probably from the southwest or south.

A high-pressure area of 30.9 inches was central over the Gulf of St. Lawrence, with a low 29.75 inches over extreme eastern Tennessee, and another of 29.75 inches on the Virginia coast. From the latter center a line of discontinuity extended approximately eastward off the coast. From this line, a surface of discontinuity sloped northward in the free air, as indicated by the fact that it was sleeting at New York. No doubt along this surface there was considerable mixing due to turbulence and it seems probable to Professor Humphreys and myself that a small disturbance passed over New York City in the free air in this turbulent layer. If we take the distance from Atlantic City to New York as 100 miles and the time interval as 1 hour and 45 minutes, the rate of travel of the disturbance was in the neighborhood of 55 to 60 miles per hour.

A phenomenon of this character has also been noted by Sir Napier Shaw in his Forecasting the Weather, first edition, pages 253, 254.—*R. H. Weightman.*

A DENSE SMOKE CLOUD ON JANUARY 3, 1929, AT WASHINGTON, D. C.

551.510.4 (753)

By IRVING F. HAND

[Weather Bureau, Washington, January 9, 1929]

Cold mornings with little or no wind and consequent piling up of city smoke have been productive of many noteworthy smoke clouds which have passed over the Solar Radiation Observatory of the Weather Bureau, located on the campus of the American University in the northwest suburbs of Washington,[1] but none heretofore has yielded as many dust particles as the cloud which passed over this section of the city about 9:30 a. m., January 3, 1929. The American University is located about 2 miles from Georgetown, an industrial center of Washington, 4 miles northwest of the White House, and 5 miles from all important railroads.

Table 1 shows in condensed form the number of dust particles collected by both the Owens[2] and Hill[3] dust counters, together with certain meteorological data. Not only was the number of these particles the maxima ever obtained in Washington, but their size averaged about 0.0015 mm. in diameter, or about twice the diameter of those usually collected.

TABLE 1.—*Number of dust particles and meteorological data during the passage of a dense smoke cloud over northwest Washington, January 3, 1929*

Time	Number of dust particles: Owens counter		Number of dust particles: Hill counter	Temperature	Rel. hum.	Vapor pressure	Wind: Direction	Wind: Velocity	Visibility: West	Visibility: East
	Per cu. cm.	*Per cu. ft.*	*Per cu. ft.*	*°F.*	*Per cent*	*Inch*			*Miles*	*Miles*
8:00 a. m.	638	18,066,246	18,788	24	64	0.063	0	0	12	1
9:30 a. m.	12,810	363,637,470	469,700	27	53	.076	S.	2	3	¼
Ratio {9:30 a. m. / 8:00 a. m.}		20.1	25.0							

[1] Mo. Wea. Rev., 1925, 53: 147–148. Mo. Wea. Rev., Jan., 1926, 54: 19–20.
[2] Mo. Wea. Rev., Mar., 1924, 52: 133–139.
[3] It collects the particles in a measured quantity of air by causing them to impinge upon the object glass of a microscope, the surface of which is covered by a thin coating of white vaseline.

The ratio of the 9:30 a. m. to the 8 a. m. measurements by each instrument indicates a greater increase in the coarse than in the fine particles, since the microscope used with the Hill instrument magnifies only 80 diameters, which makes visible particles 0.0001 inch, or 0.00254 mm. in diameter, while a microscope magnifying 1,000 diameters is used to count the dust collected by the Owens instrument, which makes visible particles having a diameter somewhat less than the shortest wave length of visible light, or about 0.0002 mm.

The effect of this cloud upon the amount of solar radiation received from the sun at normal incidence is striking. A pyrheliometric measurement at 9:03 a. m. gave an intensity of 0.79 gram-calory per minute per square centimeter of normal surface through an air mass of 4 (solar altitude = 14.3°). The following observation, at 9:26 a. m., and through air mass 3.5 (solar altitude = 16.4°) gave a value of 0.22, or one-fourth of what would have been expected had the sky remained free from smoke.

On Figure 1, curve 1 is a reproduction of the actual trace made by the recording Engelhard microammeter of the amount of radiation received directly from the sun and diffusely from the sky during the morning of January 3, while curve 2 is a copy of a trace made by the same instrument four days later when the early morning and noon intensities approximated those of January 3, but with a smoke-free atmosphere throughout the day. This latter trace fairly well represents the amount of radiation we would have expected during the morning of January 3 had the sky remained uncontaminated by smoke. It will be seen that the loss of solar energy amounts to over 60 per cent at 9:30 a. m., the greater part of which was due to reflection of the radiation back into space from individual particles, although a small proportion was absorbed. The curves do not show, however, the well-known fact that a much larger percentage of short-wave radiation is cut off by a smoke cloud than of the long-wave radiation.

The thickness of the smoke cloud was estimated to be at least 100 feet, and while it might have been slightly less dense near the top than at the bottom, convection had set in strong enough to carry many particles to heights greater than 100 feet. Using the measurements by the Owens dust counter, the number of dust and smoke particles averages $363,637,470 \times 27,878,400 \times 100 = 1,011 \times 10^{15}$ over each square mile of surface area. This number, in connection with the average diameter given above gives 110 cubic feet of suspended matter. As soot piled loosely weighs about 42 pounds per cubic foot, we obtain 4,620 pounds of solid matter in the atmosphere over each square mile covered by this smoke cloud.

The material in this cloud was evidently made up principally of products of combustion or smoke. The odor of sulphur trioxide, SO_3, was very noticeable, and it has been found that the combination of water vapor with this gas forms sulphuric acid, in sufficient quantities to be injurious to metal work and masonry in buildings. In addition there were the usual number of spores, fungi, soil and rock materials, decayed vegetable matter, and other objectionable materials.

A normal adult will inhale about 18 times a minute, and with each breath will draw about 30 cubic inches of air into his lungs, or 540 cubic inches per minute. Therefore, while standing in the smoke cloud of January 3 he would have drawn about 113,000,000 solid particles into his respiratory system during each minute.

Since these particles in connection with moisture are injurious to building material, we would expect them to have a deleterious effect upon lung tissues, and such is undoubtedly the case. That the respiratory system of the human body is able to withstand such contaminating influences without serious results is testimony to its wonderful efficiency.

This smoke cloud was no more dense than is frequently found over the center of large industrial cities. For example, two cities have reported over 500,000 particles per square foot, as measured by the Hill dust counter on several days in December, 1928.

There is some consolation to dwellers in Washington to know that this cloud is twenty-two times as dense as that ordinarily found at the American University during the three winter months, January, February, and March, and eight times as dense as that found over the Weather Bureau in the city proper during the same period.

Continuous or even frequent exposure to smoke clouds of this character has a tendency to weaken the powers of resistance of the respiratory organs to disease. In addition, the ultra-violet rays in sunlight, which are powerful germicides, are completely shut out. This still further increases the opportunity for the spread of disease in cities with smoke-filled atmospheres.

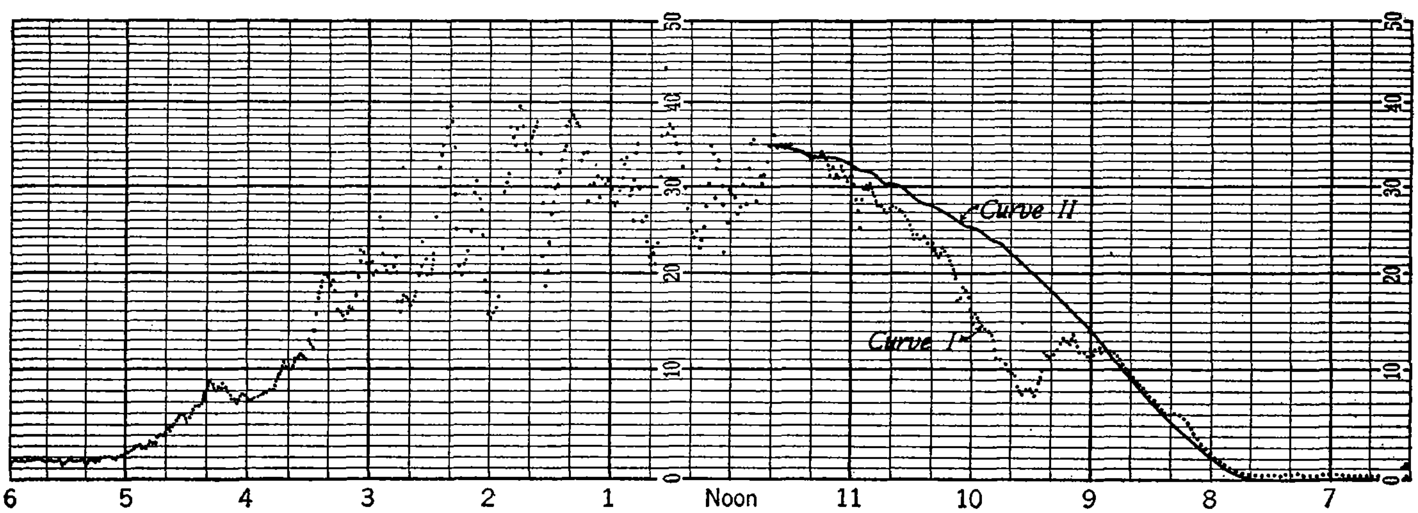

FIGURE 1.—Pyrheliometric record, American University, D. C., January 3, 1929